TECHNICAL INFORMATION

COATINGS:
To insure maximum protection for the resistance wire, Huntington Electric's vitreous enamel and silicone coatings are compounded from highest quality materials to our own exacting formulation. The vitreous enamel offers superior environmental and mechanical protection. The silicone coating which is cured at high temperatures for maximum environmental and solvent resistance, is well suited for applications requiring very low or high ohmic values and close resistance tolerances in addition to offering cost savings.

AMBIENT TEMPERATURE:
Because the maximum permissible operating temperature is a set amount, increases in the ambient temperature subtract from the permissible temperature rise and therefore, reduce the permissible watt load. See Figure 1.

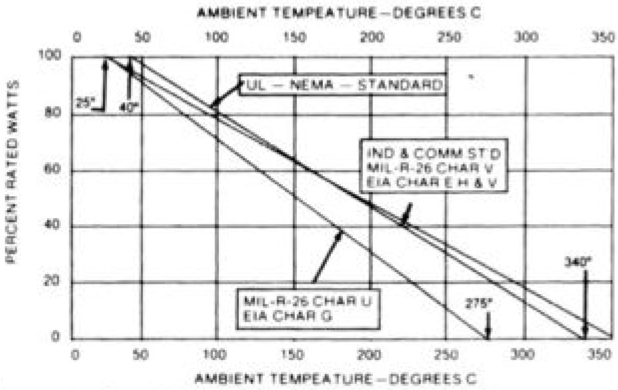


Figure 1 - Derating of Resistors for High Ambient Temperatures.

GROUPINGS:
Resistors placed close to each other show an increased hot spot temperature for given wattages because of heat radiating from one to the other and the increased heat per unit volume of air available for convection cooling. See Figure 2.

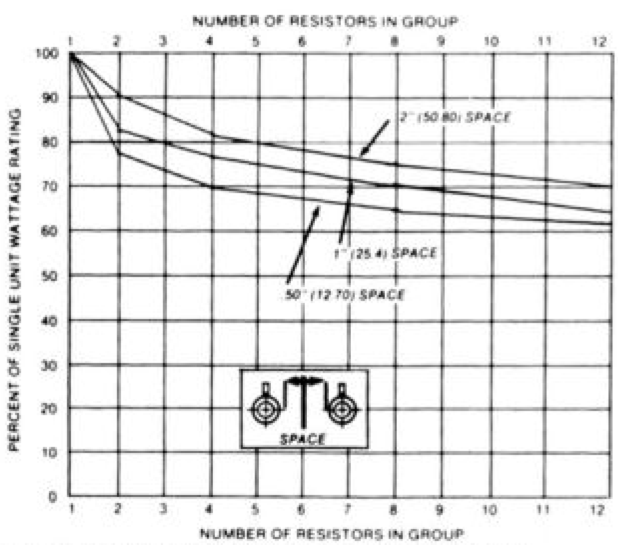


Figure 2 - Derating of Resistors to Allow for Grouping.

ALTITUDE:
The amount of heat which air will absorb varies with the density, and therefore with the altitude above sea level. For typical derating, see Figure 3.

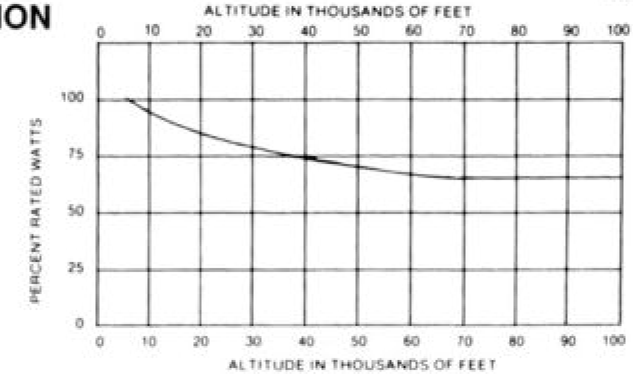


Figure 3 - Derating for Altitude.

COOLING AIR:
Forced circulation of air over a resistor removes more heat per unit time than natural convection and therefore permits an increased watt dissipation. Special mountings can also increase the rating. A typical curve is shown in Figure 4.

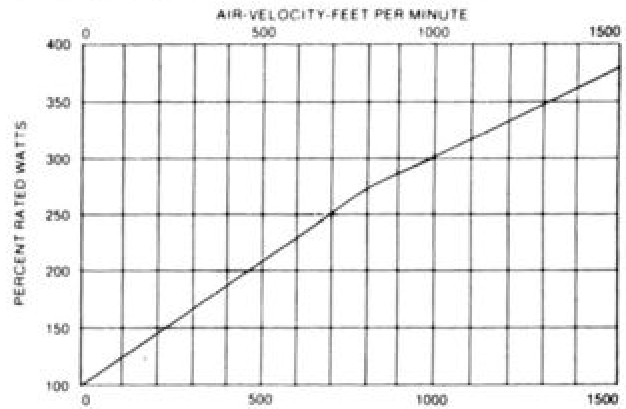


Figure 4 - Percent of Free Air Rating for Typical Resistor Cooled by Forced Air Circulation.

LIMITED TEMPERATURE RISE:
In order to keep the temperature rise low, it is often desirable to operate a resistor a fraction of the Free Air Watt Rating. This procedure may be used to insure maximum life, to protect adjacent heat sensitive apparatus or to hold the resistance value very precisely both with changing load and over a long period of time. When it is desirable to operate a resistor at less than maximum temperature see Figure 5.

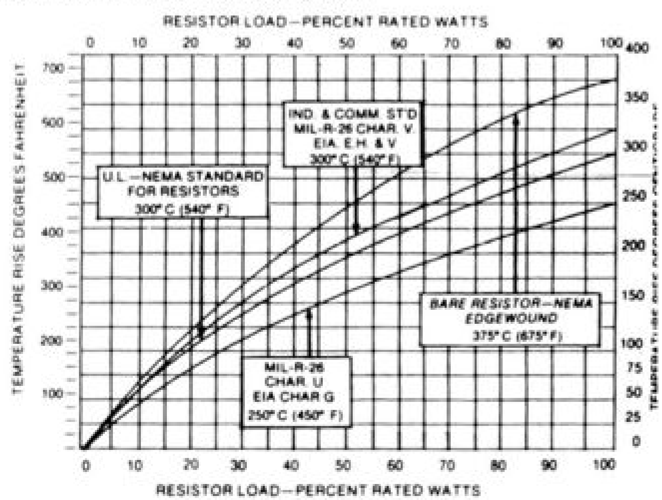


Figure 5 - Approximate hot spot temperature rise of a resistor in free air for various specifications.

TEMPERATURE COEFFICIENT:
Temperature coefficient is measured in parts per million per degree Centigrade or PPM/° C. All resistance wire is affected by changes in temperature. This change in resistance per degree change in temperature is called the temperature coefficient or TC.

The commonly used low TC resistance wires of 800 and 294 ohms per circular-mil-foot are rated by the wire manufacturers as having TC's of 0 ± 20 PPM/°C. This implies that although the nominal value of the TC is zero, the actual value may be anywhere between +20 PPM/°C and -20 PPM/°C.

The TC of a completed resistor may be different from that of the original wire. This is because the TC may be affected by heat treatment during processing and/or materials and methods of construction. Theoretical changes in resistance with temperature are shown in Figure 5. For critical applications, the TC should be specified. TC may be calculated as follows:

$$TC = \frac{(R-r)\ 100}{(tR - tr)R}$$

R = Resistance at Reference Temperature
tR = Reference Temperature in Degrees C
r = Resistance at Test Temperature
tr = Test Temperature in Degrees Centigrade

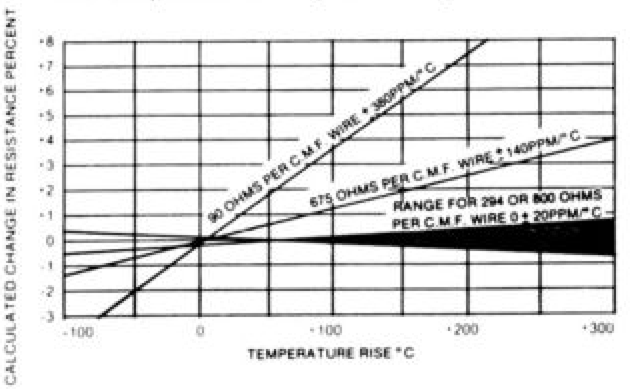


Figure 6 - Calculated change in resistance with nominal TC assumed constant.

PULSE OPERATION:
As a pulse of power, when averaged over the total on and off time, results in less heat per unit time than for continuous duty, temperature rise is also affected. This may allow higher power during the pulses. The exact temperature rise varies with each resistor depending on size, ohmic value, winding, etc. Consult factory for details for specific applications.

ENCLOSURE:
Enclosures limit the dissipation of heat by convection currents in the air and by radiation. Enclosure walls also create a thermal barrier between the air contacting the resistor and the outside cooling air. Therefore, size, shape, orientation, number of ventilating openings, wall thickness, material and finish all affect the temperature rise of the enclosed resistor. Because of the many variables involved, typical derating will vary from 15% for open mesh enclosures to 100% for total enclosure.

HIGH RESISTANCE:
High resistance units, which require the use of very small diameter wire, should generally operate at reduced temperature for maximum reliability.

HIGH VOLTAGE:
Under normal conditions, a maximum voltage gradient of 500 volts R.M.S. (705 volts peak) per inch of winding length is recommended. Consult factory for higher gradients in pulse applications or for other special conditions.

HIGH FREQUENCY:
For use at radio and supersonic frequencies, non-inductively wound resistors are generally required.

Basic Resistor Equation

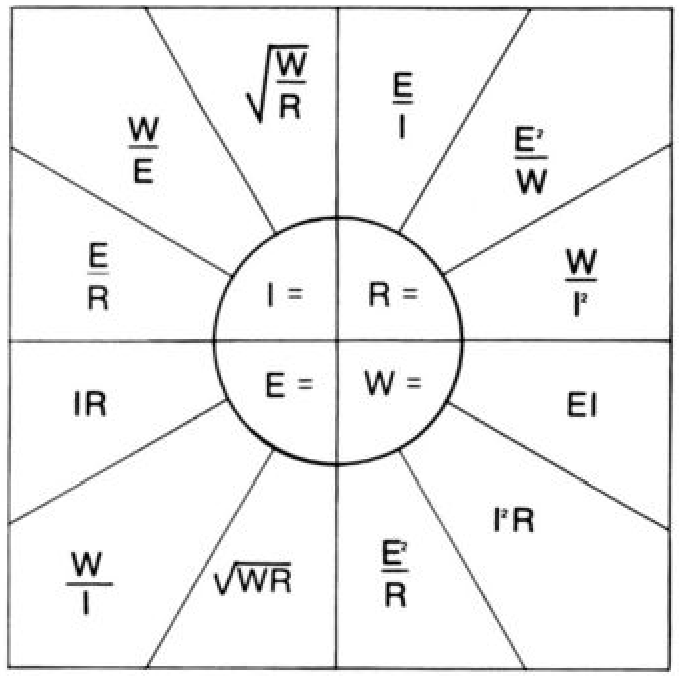
Resistance in Series.

$R_T = R_1 + R_2 + R_3 \text{ ---- } + R_n$ ohms

Resistance in Parallel.

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \text{ --- } \frac{1}{R_n}} \text{ ohms}$$

ohm's law equations for D.C. circuits



W = POWER (WATTS)
R = RESISTANCE (OHMS)
I = CURRENT (AMPS)
E = VOLTAGE (VOLTS)

ohm's law equations for D.C. circuits

I Amps	$\frac{E}{Z}$	$\frac{W}{E \cos\theta}$	$\sqrt{\frac{W}{R}}$	$\sqrt{\frac{W}{Z \cos\theta}}$		
E Volts	IZ	$\frac{W}{I \cos\theta}$	$\frac{\sqrt{WR}}{\cos\theta}$	$\sqrt{\frac{WZ}{\cos\theta}}$		
W Watts	$EI \cos\theta$	$\frac{E^2 \cos\theta}{Z}$	$I^2 Z \cos\theta$	I^2R		
R Ohms	$\frac{E}{I} \cos\theta$	$\frac{(E \cos\theta)^2}{W}$		$Z \cos\theta$	$\frac{W}{I^2}$	$\sqrt{Z^2 - X^2}$
Cos θ Power Factor	$\frac{IR}{E}$	$\frac{W}{I^2Z}$	$\frac{WZ}{E^2}$	$\frac{R}{Z}$	$\frac{W}{EI}$	$\frac{R}{\sqrt{R^2+X^2}}$
Z Ohms	$\frac{E}{I}$	$\frac{W}{I^2 \cos\theta}$	$\frac{R}{\cos\theta}$	$\frac{E^2 \cos\theta}{W}$		$\sqrt{R^2+X^2}$
X Ohms	$(X_L - X_C)$		$\left(\frac{2\pi fl - 1}{2\pi fC}\right)$			$\sqrt{Z^2-R^2}$

C = Capacitance
L = Inductance
X_C = Capacitive Reactance
X_L = Inductive Reactance
Z = Impedance
θ = Angle of lead or lag
f = Frequency